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PER-ACRE PRICING--
ITS EFFECT ON LOGGING RESIDUE

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Abstract

Results are presented of a study designed to test the effectiveness of a combination scale-lump sum timber selling procedure in reducing the volume of logging residue. A comparison was made between National Forest sales by the traditional scale method with a new method incorporating both scale and per-acre pricing of material with less than 80 board feet of volume. Residue volumes were adjusted by covariance analysis to account for the differences in four sale characteristics. Results indicate that, although a difference in average residue volumes occurred between the two sale procedures, the averages were not significantly different at the 5-percent probability level.

KEYWORDS: Slash disposal (-fuel reduction, timber marketing, log value.

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Introduction

This paper compares two methods used by the U.S. Forest Service in Oregon and Washington for selling standing timber. One method (scale sales) applies a set price per thousand board feet, by species, to the log scale or the measured amount of timber removed. The other method (*p*er-*a*cre *m*aterial or PAM sales) sells all logs below a given net volume (80 board feet in this study) for a lump sum per acre with larger logs sold on a scale basis. Special peelers (cull peelers) or utility grade logs of any size are also included in the per-acre pricing.

The purpose of the PAM method is to encourage the logging operator to remove more of the low value material that might otherwise be left as logging residue. Removal of this material helps accomplish several objectives of the land manager, including better use of the timber resource, reduced fire hazard, reduced need for slash burning, and improved appearance of the area after logging.

Per-acre pricing allows removal of the low value material without a direct stumpage charge, since it has already been paid for in the fixed cost per acre. In the log scale method the net volume of each piece is measured and paid for at the full stumpage rate for that species. The assumption is that the purchaser will remove more of the total wood volume if he does not have to pay any scaled stumpage charge for the low value pieces. Major arguments for and against log scale and lump sum selling procedures can be found in "Log-scale and lump-sum timber selling on Federal lands in western Oregon" (*2*).

For example, small diameter logs contain less volume than larger logs, yet take as much or more time to handle in the yarding and loading process. The cost per thousand board feet is therefore greater for smaller logs and the cost:return break-even point is higher. If a stumpage cost is added to the logging cost, the break-even point becomes even greater and less volume would be removed.

The same problem occurs with log defect. A log with some defect that just pays its way without any direct stumpage charge will become uneconomical to the purchaser if it must be scaled and a stumpage charge assessed for the added volume removed.

The effect of lump sum pricing is to make all the stumpage charge a fixed cost to be borne by the sale as a whole, rather than related to the scale of any given log.

The results of this study should be useful in guiding public timber selling agencies toward the most appropriate methods of marketing stumpage. Timber buyers may also find the study useful in helping to formulate a decision on how timber might best be marketed.

Objective and Procedure

The objective of this study was to measure the effectiveness of the combination log scale-lump sum timber selling procedure in reducing logging residue compared with the traditional log scale method.

The study procedure was to compare the volume of logging residue left on an equal number of clearcut sale areas made under each of the two sale methods. Timber on half the areas was sold by the standard selling procedure of charging a fixed price per thousand board feet for all material removed (scale sales). Timber on the remaining areas was sold for a fixed price per thousand board feet for all material over 80 board feet and a lump sum per-acre price for all material measuring less than 80 board feet (PAM sales).

A total of 38 clearcut areas were measured in the study, 19 for each sale method. Sample size was influenced by the availability of PAM sales and the budget constraints of the study. The 38 areas were randomly selected from the total number of clearcut areas that fulfilled all the conditions described below.

The following limitations were placed on the population of sales from which the sample was drawn to minimize variation due to factors other than sale procedure:

1. All areas were located in western Oregon or southwestern Washington. Sale location could have a strong influence on the volume of residue left after logging because market opportunities can vary widely between timbersheds. The study area selected was as geographically small as possible while still offering a sufficient population of sales from which to draw the sample.

2. Logging was completed during calendar year 1971. Market conditions in the wood products industry show sharp, short-term fluctuations. To minimize the effect of these changing conditions, sale completion was limited to 1 year.

3. All areas contained at least 500,000 board feet of timber.

4. Clearcut logging was specified on all areas.

5. All areas were part of regular harvest cut sales (not salvage sales).

6. All areas were cable yarded.

7. No area had a YUM (yarding unmerchantable material) requirement.

8. All areas were to be unburned prior to sampling. The original list of sales obtained for each National Forest had no previously burned areas. However, in some cases, burning occurred between the time the sample was

selected and residue measurements were taken. These areas were replaced with alternates selected at the time the original sample was taken.

There are other sale characteristics that could influence the amount of residue left after logging. Data were collected for four characteristics, and residue volume on individual sales was adjusted to account for their influence. The four sale characteristics and their expected influence were:

1. Gross cruise volume of timber per acre was expected to be positively associated with residue volume; that is, as cruise volume increased, residue volume was expected to increase. The logic of this assumption is that a larger volume of timber growing on the area should result in a larger volume of residue material.

2. Average slope of the sale area was expected to be positively related to residue volume. With steeper slopes, logging difficulty would increase and more low value material would be left behind.

3. Stand age should be positively associated with residue volume. This variable should help account for size differences; the older the stand, the larger the trees. Stand age may also be closely associated with the fourth characteristic (percent stand defect) since older stands would be expected to have more defect. Both larger size and additional percent defect should increase volumes of residue.

4. Percent stand defect was expected to be positively associated with residue volume. As more defect is encountered, less of the total volume of material can be economically removed.

Method of Measuring Residue Volume

The line intersect method of estimating logging residue volume was used in this study (*1*, *5*, *6*). Because of problems with uneven distribution of residue and varying sizes and shapes of clearcut tracts, an alternative to the continuous line intersect approach was used. This alternative, tested and recommended for measuring residue on cable logged areas by Howard and Ward (4), uses a systematic grid-point sampling design. Howard and Ward's results indicate that about 40 sampling units are needed to meet a degree of precision of at least 20-25 percent on each clearcut area at the 95-percent confidence level. This number of 200-foot sampling units per clearcut area is about the most an inventory crew can measure in 1 day.

A 40-point grid was laid on each clearcut area. The spacing interval between grid points was the same within each clearcut but varied between clearcuts depending on their size. From each grid point, measurements were made along a 200-foot randomly oriented line. All pieces 3.5 inches or more in diameter and 4 feet or longer were measured. Estimates of the percent soundness of the cross section at the point of intersection with the line transect were recorded to obtain net volumes of residue. These estimates were based on observed defects of each piece, without bucking, at the point of intersection.

Study Results

Average gross and net chippable residue volumes per acre for each method are:

Method	Measured average volume	Adjusted average volume
	----- *Cubic feet* ----	
Scale sales:		
Gross	2927.3	2604.7
Net	1789.0	1663.0
PAM sales:		
Gross	1914.4	2237.0
Net	1258.5	1384.3

The measured average volumes were statistically adjusted to eliminate the variation between the mean volumes attributed to the differences in the observed stand characteristics, i.e., gross cruise volume, average slope, stand age, and percent stand defect. The adjusted volumes were used for a statistical comparison between the average volumes of the two sale methods. The average values of the sale characteristics by type of sale were:

Sale characteristics	Unit of measure	Scale sales	PAM sales
Gross cruise volume	M fbm/acre	70.0	61.3
Average slope	Percent	34.7	36.5
Average stand age	Years	309	211
Average stand defect	Percent	34.5	25.2

Gross cruise volume, stand age, and stand defect were all appreciably higher on the scales sales. Only percent slope, which was slightly greater for PAM sales, did not show a large difference between the two types of sales. Because the values for each characteristic are different between sale types, the two groups of sales would be expected to have a different average residue volume regardless of sale method. To eliminate the influence of the unequal values of the independent variables, the average residue volume for

each sale type was statistically adjusted.[1/] The adjusted average gross residue volumes were 2,604.7 cubic feet per acre for scale sales, and 2,237.0 cubic feet per acre for the PAM sales, a difference of 14.1 percent. Corresponding adjusted volumes for net chippable material were 1,663.0 and 1,384.3 cubic feet per acre for scale and PAM sales, respectively, a difference of 16.8 percent.

Conclusions

Results of this study show only a weak statistical basis for concluding that the PAM method of timber sale yields less residue than the scale method.

Four sale characteristics, taken together, do explain a significant amount of the variation in gross logging residue.[2/] These are cruise volume, slope, stand age, and percent of stand defect. The importance of these factors indicates that the total environment within which the timber sale is made may be the key to why varying amounts of residue are left after timber is harvested. Further study of the physical characteristics of the timber and the timber sale area, together with consideration of economic and institutional factors, such as timber sale policy, surrounding the harvest operation, may provide a means for more accurately forecasting residue conditions on harvested areas.

Moreover, the decision of the land manager to offer scale or PAM sales can also rest on other factors such as efficiency of scaling and sale administration, the need for more accurate cruising and appraisal methods, and consideration of possible changes in operators' bucking practices.

[1/] The measured average volume of each sale method was adjusted by covariance analysis. These adjusted averages were then used to test the hypothesis that the average volumes of residue of the two methods were equal. The results of the test indicated that the average volumes were not significantly different at the 5-percent probability level. However, the averages were significantly different at the 10-percent probability level--not strong statistical evidence for concluding a real difference exists between the two methods in generation of residue.

[2/] Multiple regression analysis showed that differences due to the combined effect of four sale characteristics--cruise volume, slope, stand age, and percent stand defect--are statistically significant. The relationship of these factors to residue volume for the combination of both sale methods is estimated by the regression equation:

$$Y = 1161 + 9.835X_1 - 28.42X_2 - 0.1559X_3 + 55.84X_4$$

where

Y = Gross residue volume per acre, in cubic feet

X_1 = Gross cruise volume per acre, in thousand board feet

X_2 = Slope, in percent

X_3 = Stand age, in years

X_4 = Percent stand defect

Data were collected for this study in 1972 for timber sale areas logged in 1971. The PAM sale procedure was relatively new in 1971, and as the Forest Service and sale purchasers gain experience with the procedure, residue volumes may change on PAM sale areas. Residue volumes on both PAM and scale sale areas may be affected by economic conditions of industry at the time of harvest. Year-to-year variations in economic conditions may cause year-to-year variations in residue volumes.

The demonstrated importance of the four measured timber sale characteristics and the possible effect of other factors surrounding a timber sale may have important implications regarding the design and selection of timber sale methods. In particular, the findings suggest that a single sale procedure for all timber sales may not offer the best alternative for reduction of residue. Instead, the most appropriate approach may be to vary the procedure according to each sale's particular characteristics.

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Appendix

Multiple regression analysis for the four variables, cruise volume, slope, stand age, and percent stand defect, had a coefficient of multiple determination, R^2, of 0.67. This means that 67 percent of the variation can be explained by these factors. Analysis of covariance gave the common regression equation shown in footnote 2, p. 5.

The test of significance gave an F value of 2.34, for 4 and 28 degrees of freedom. To meet the 5-percent probability level, the F value would have to be 2.64 or greater. However, the 10-percent probability level requires an F value of only 2.11. Therefore, the test was significant between the 10- and 5-percent probability levels.

The negative coefficients for stand age and slope at first glance seem inconsistent, yet may be explained by interaction among the four variables. No cause and effect relationship can be inferred from the sign of the coefficients in the regression equation in footnote 2.

Our analysis was based on gross residue volume, because results for net volume had much greater total variation due to the difficulty of judging net volumes accurately in the line transect method. Statistical tests gave much lower levels of significance for the net volume analysis.

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